Three-day changes in resting metabolism after a professional young rugby league match

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Headline

Professional collision-sport athletes report uniquely large energy expenditures across the season (1-4), as determined by gold standard assessment of resting metabolic rate (RMR (5)) and total energy expenditure (TEE (6)). Such expenditures are possibly a consequence of strenuous match demands, which repeatedly expose players to substantial exercise- and collision-induced muscle damage (7). Recovery from such large perturbations of homeostasis (8) are likely to be energetically expensive (9), in part determining the distinct in-season energetic demands of professional collision-sport athletes.

Aim. Accurately determining the effect of match play on resting metabolism is essential to optimise acute manipulation of energy balance, player recovery and long-term athlete development. Therefore, for the first time this case report investigated the metabolic cost of a professional young rugby league (RL) match.

Methods

Athletes. Five healthy, professional young male RL players (mean (standard deviation; SD) age; 18 (1) years, height; 182 (5) cm, body mass (BM); 92.4 (15.1) kg) were recruited for this study. Eight participants originally volunteered; however, three were excluded from analysis because they failed to complete all required assessments. Participants were chosen from a range of playing positions (Table 1). All participants provided written informed consent prior to volunteering. Ethics approval was granted by the Research Ethics Committee (Leeds Beckett University, UK).

Design. Study data were collected over a four-day period, during the sixteenth week of the playing season. The assessment period included one competitive match (Day 0; 12:00 pm kick off) and three strictly enforced rest days (Days 1-3). Each morning after an overnight fast, participants attended the lab for RMR assessment (06:30 - 09:00). After RMR and anthropometric (height & fasted BM) assessment on Day 0, participants were provided with a typical match day breakfast, which was consumed *ad libitum*. Across the assessment period, participants were encouraged to partake in typical individualised recovery strategies, although no recovery strategies were reported.

Methodology. *Resting metabolic rate.* Throughout the assessment period, participants underwent overnight fasts and fifteen-minute enforced rest periods before the beginning of fifteen-minute RMR assessments. Each assessment occurred within a temperate room (21°C) with participants fitted with a face mask and lying quietly in a supine position (5). Expired gas was analysed using an online gas analyser (Metalyzer 3BR3, Cortex, Leipzig, Germany). The gas analyser was calibrated as per the manufacturer guidelines. Data across the entire collection period were subsequently averaged every 30 s to remove artefacts and exported to Microsoft Excel (2016, Seattle, USA). The respiratory exchange ratio was determined from $\dot{V}O_2$ and $\dot{V}CO_2$ measurements (10). Expenditure was estimated from substrate oxidation rates and expressed per 24 hours, using an energy value for carbohydrate and fat of 3.75 kcal and 9 kcal, respectively (11).

Match Loads. Individual player match loads are reported in Table 1. Internal and external loads were assessed via sRPE (12) and micro-technology units (Optimeye S5, Catapult Innovations, Melbourne, Australia; version 5.27, 13.2 (2.5); horizontal dilution of precision 0.9 (0.1)), respectively. Microtechnology units were turned on fifteen minutes prior to the match in a clear outdoor space to achieve a satisfactory satellite lock. The match was also filmed (video camera; Canon XF105) and coded for collisions (tackles and hit-ups) by an expert analyst using Sportscode (Sportec, NSW).

Statistical analysis

Raw data are presented as mean (SD). Magnitude-based inferences were used to assess for differences in RMR between baseline and 24, 48 and 72 hours post-baseline. The threshold for a change to be considered practically important (the smallest worthwhile change) was set at 0.2 x between subject SD, based on the Cohen's d effect size (ES) principle (13). Throughout analysis, Cohen's d was adjusted to hedges g to

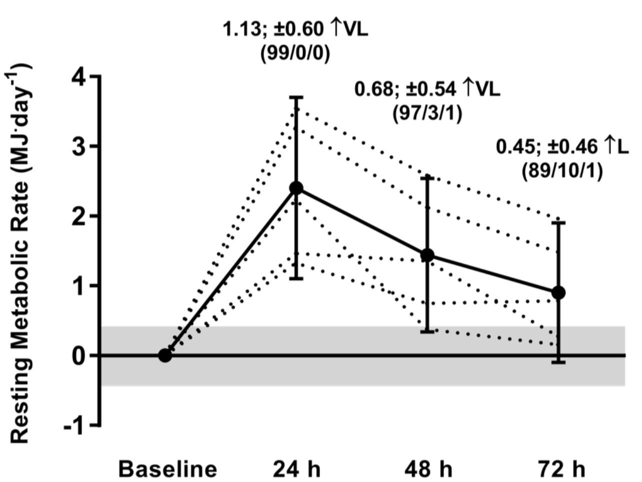

Fig. 1. Mean and individual RMR data across the four-day assessment period. Ratings of probability refer to within-group changes: VL, very likely; L, likely and ↑, increase. Effect size; ±SD, refer to differences in raw data. The shaded area equals the threshold for the smallest worthwhile change (0.42 MJ.day^{-1}). Bracketed values represent the percentage chance that the true value is substantially positive, trivial or substantially negative.

Table 1. Individual and mean (SD) internal and external match loads.

Internal & External Match Loads	Participant 1 Wing	Participant 2 Prop	Participant 3 Fullback	Participant 4 Loose Forward	Participant 5 Prop	Mean (SD)
sRPE (AU)	770	288	472	484	621	527 (180)
Total Distance (m)	7098	3493	5541	5439	5716	5457 (1287)
Meters per Minute (m/min)	83	85	94	90	83	87 (5)
PlayerLoad™(AU)	627	335	532	579	613	537 (119)
High Speed Running (>5 m/s)	455	156	412	280	225	306 (126)
Sprint Distance (>7 m/s)	89	11	21	0	4	25 (37)
Repeated High Intensity Efforts	5	7	3	3	7	5 (2)
Collisions	16	20	18	33	25	22 (7)
Minutes Played	86	41	59	61	69	63 (16)

reduce bias arising from a small sample size (<30 degrees of freedom) (14). Thresholds for ES were set as; <0.2 trivial; 0.2-0.6 small; 0.6-1.2 moderate; 1.2-2.0 large (13).The probability that the magnitude of change was greater than the practically important threshold (0.2 x between subject SD) was rated as <0.5%, almost certainly not; 0.5-4.9%, very unlikely; 5-24.9%, unlikely; 25-74.9%, possibly; 75-94.9%, likely; 95-99.5%, very likely; >99.5%, almost certainly (13). If the 95% CI crossed both the upper and lower boundaries of the practically important threshold (ES ±0.2), then the magnitude of change was described as unclear. All analyses were run in a custom built spreadsheet (15). The relationships between minutes played and changes in RMR from baseline were also described using MBI, as explained elsewhere (16). To account for differences in overall match exposure, all differences were re-evaluated for minutes played (16). Due to the small sample size, additional covariates were not considered for analysis.

Results

Mean and individual RMR changes from baseline are shown in Figure 1. There was a 2.38 (1.02) MJ.day^{-1}, 1.44 (0.93) MJ.day^{-1} and 0.94 (0.78) MJ.day^{-1} increase in RMR at 24 (12.58 (1.67) MJ.day^{-1}), 48 (11.64 (1.78) MJ.day^{-1}) and 72 hours (11.14 (1.81) MJ.day^{-1}) from baseline (10.2 (1.68) MJ.day^{-1}), respectively. The relationship (r; 95% confidence interval) between change from baseline and minutes played was possibly very large at 24 (0.83; ±0.59), unclear at 48 h (0.63; ±0.77) and likely very large at 72 hours (0.88, ±0.50). When adjusting for mean minutes played, changes in RMR from baseline were almost certainly higher at 24 hours (1.13; ±0.44), and very likely higher at both 48 (0.68; ±0.56) and 72 hours (0.45; ±0.29).

Discussion

This is the first study to investigate the effects of competitive RL match play on prolonged RMR responses in professional young collision sport athletes. The results highlight a substantial elevation in RMR, which peaked 24 hours after baseline and was still elevated after 72 hours. These findings have immediate implication within professional collision-based sports, ensuring athletes consume a sufficient intake after match-play to meet their distinctly large energetic recovery profile, alongside the additional demands of training, home-based loads and development. Consequently, practitioners and coaches are encouraged to regularly assess and behaviourally support desired manipulation of energy balance following match-play via regular standardised player BM assessment, especially within young and developing cohorts.

This case report presents novel RMR data for professional young RL players before and for three days after a competitive match, highlighting a substantial elevation in resting metabolism of ∼568 kcal.day^{-1} at 24 hours post-baseline and a combined increase of ∼1135 kcal across the entire assessment period. Previous research has illustrated increases in RMR after exercise (17, 18), however increases observed in this report are substantially larger than those typically reported after endurance or even resistance-based exercise (19). For example, 60 sets of whole-body resistance exercise performed to failure increased the resting metabolism of seven healthy men by 180 kcal.day^{-1} (20), whereas 50 sets of whole-body resistance exercise and 100 Smith-machine squats increased participant RMR by 90 kcal.day^{-1} (21) and 218 kcal.day^{-1}, respectively. Consequently, the increase in RMR observed in this case report illustrates the exaggerated energetic recovery cost of professional young RL match play; possibly elucidating the distinctly large in-season expenditures reported for professional collision-sport athletes (3, 4).

In this case study RMR was still elevated by an average of ∼224 kcal at 72 hours post-baseline, potentially depicting a similar recovery trajectory as markers of physiological fatigue following competition (8). Professional collision sport match-play elicits reductions in neuromuscular function (22-24), elevations in indirect markers of muscle damage (25-27), alterations in immune and endocrine function (28) and self-perceived decrements in wellbeing and mood (28). Such perturbations typical persist between 24 and 72 hours , although can persist for up to four days after competition (28). Interestingly, individual energetic recovery profiles varied, as is commonly reported for markers of physiological fatigue post-competition (24). Considering that markers of fatigue are typically accredited to substantial muscle damage sustained during match-play (7, 8), it appears pertinent for professional collision-sport athletes to be practically encouraged to (re)fuel appropriately for the “muscle damage caused” along-side the kinematic “work required” of competition (9).

Practical applications

- Five-hundred and sixty-eight calories represents a large additional energetic requirement in the 24 hours after professional RL match-play, practically expressed as ≈6.5 medium bananas or an additional meal.
- Athletes can typically exhibit gastrointestinal distress after competition, especially after damaging repeated high intensity bouts and collisions typical of RL match play. Thus, suggested nutritional solutions should prioritise palatability and practicality, alongside nutritional value to behaviourally support consumption.
- For example, players could be provided with a bespoke shake to consume in addition to the post-match meal at home on match day and match day plus one. Shakes should prioritise high quality proteins (i.e. milk, Greek yoghurt, batch tested whey), a mixture of monosaccharides (specifically glucose & fructose, i.e. honey & frozen fruits), phytonutrients (i.e. berries, batch tested tart cherry), fluids (coconut water, fruit juices, milks) and high-energy palatable foods (i.e. ice-cream, Nutella or peanut butter).

Limitations

- The findings of this case report are based on a small sample size (n=5) from only one competitive match, thus findings may lack generalisability and require replication.
- The inclusion of direct or in-direct markers of muscle damage would have strengthened study hypotheses by linking observed increases in RMR to potential increases in muscle damage sustained during match-play.

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